INTRODUCTION

The National Imagery and Mapping Agency publishes a List of Lights, Radio Aids and Fog Signals in seven volumes divided geographically as shown on the index chartlet on the inside front cover of this book. Major fixed and outermost floating aids to navigation, such as sea buoys, safety fairway buoys, traffic separation buoys, etc., are listed. Other floating aids are not generally listed. Storm signals, signal stations, radio direction finders, radiobeacons, RACONs and RAMARKs located at or near lights are found in this List. Radiobeacons are listed in a separate section in the back of this publication.

The date to which this publication has been corrected can be found in the Preface. In the interval between new editions, corrective information affecting this publication will be published in Section II of Notice to Mariners, and must be applied to keep this publication current. All of these corrections should be applied in the appropriate places and their insertion noted in the “Record of Corrections.”

Mariners and other users are requested to forward new or corrective information useful in the correction of this publication to:

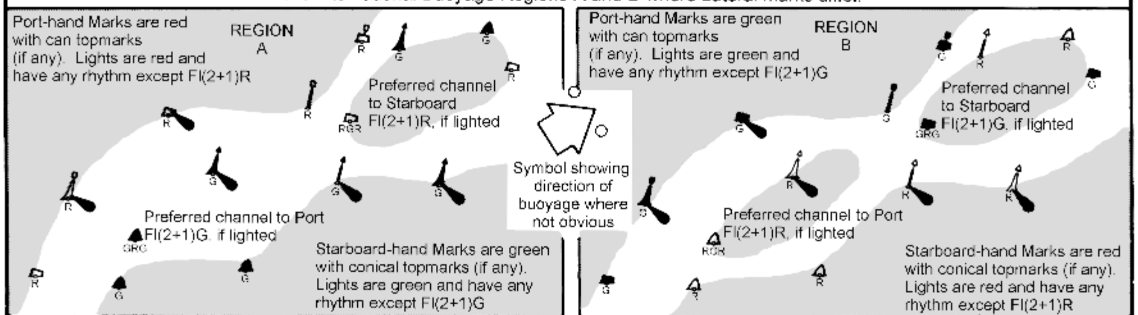
MARINE NAVIGATION DEPARTMENT
ST D 44
NATIONAL IMAGERY AND MAPPING AGENCY
4600 SANGAMORE ROAD
BETHESDA, MD 20816-5003

Buoys and Beacons IALA* Buoyage System

Where in force, the IALA System applies to all fixed and floating marks and occasionally lighthouses, sector lights, range marks, lightships and LANBY's (large automatic navigational buoys).

The standard buoy shapes are cylindrical (can), conical, spherical, pillar (including high focal plane) and spar, but variations may occur, for example lightfloats. In the illustrations below, only the standard buoy shapes are used. In the case of fixed beacons (lighted or unlighted), only the shape of the topmark is of navigational significance.

Lateral Marks (used in conjunction with a conventional direction of buoyage) are generally for well-defined channels. There are two international Buoyage Regions-A and B-where Lateral marks differ.

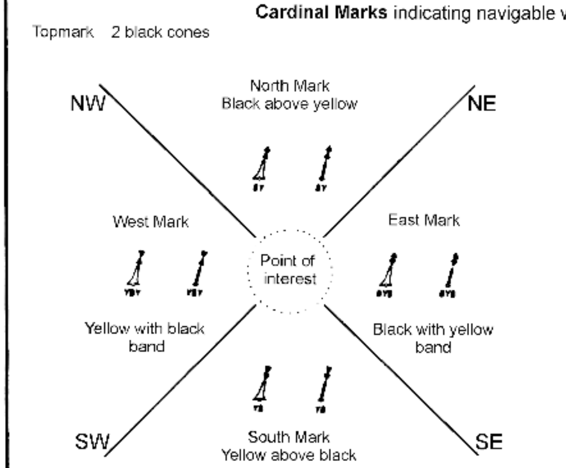


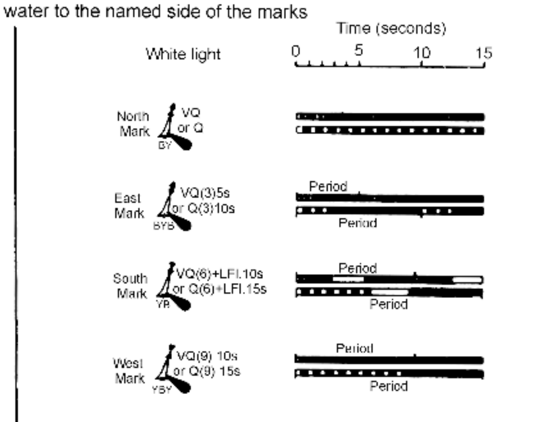
A preferred channel buoy may also be a pillar or a spar. All preferred channel marks have three horizontal bands of color

All marks other than Lateral Marks are the same in REGIONS A and B

UNLIGHTED MARKS | **LIGHTED MARKS**

Cardinal Marks indicating navigable water to the named side of the marks

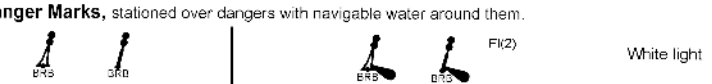




* The same abbreviations are used for lights on spar buoys and beacons. The periods, 5s, 10s and 15s, may not always be charted.

Isolated Danger Marks, stationed over dangers with navigable water around them.

Body black with red band (s)
Topmark: 2 black balls

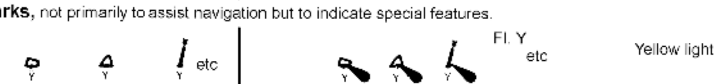


Safe Water Marks, such as mid-channel and landfall marks.

Body red and white stripes
Topmark (if any): red ball

Special Marks, not primarily to assist navigation but to indicate special features.

Body (shape optional): yellow
Topmark (if any) yellow X



BEACONS with IALA System topmarks are charted by upright symbols, eg. (minor beacon) or, on smaller-scale charts:

Beacon towers are charted: (occasionally lighted)

RADAR REFLECTORS on buoys and beacons are not generally charted.

COLOR ABBREVIATIONS under symbols, especially those of spar buoys, may be omitted, or may be at variance with symbols shown above.

LIGHTFLOATS: The IALA System is not usually applied to large lightfloats (replacing manned lightships) but may be applied to smaller lightfloats.

* IALA is an abbreviation of International Association of Lighthouse Authorities

NAVIGATION INFORMATION NETWORK (NAVINFONET)

The Navigation Information Network (NAVINFONET) is a service to mariners that allows instant access to a database of maritime safety information. The primary function of NAVINFONET is to provide the mariner with the information contained in the U.S. Notice to Mariners with selective query options to minimize the connection time and associated costs involved with data transfer over commercial communications circuits. NAVINFONET is controlled by the Marine Navigation Department of the National Imagery and Mapping Agency. Its mission is to promote safety of life at sea through up-to-date, accurate and inexpensive nautical charts and publications.

The NAVINFONET Service is web-server based and can be accessed by any customer with an Internet browser software package, a modem, and Dial-up Network software. An Internet Service Provider (ISP) is not required to access the service. The following minimal hardware and software configurations will be required to access the NAVINFONET Service via the direct dial-in connection to the NSS modem pool:

Minimum Hardware Requirements
- IBM compatible PC or Apple Macintosh
- Minimum processor: Intel 486 (PC) or 68030 (Mac)
- Minimum PC processor speed: 25MHz
- Minimum PC RAM: 8 MB
- Minimum Operating System: Windows 3.1 (PC) or MacOS 7.6.1
- Minimum modem speed: 9600 (28.8K recommended)
- Minimum available hard disk space: 35 MB

Minimum Software Requirements
- Internet browser: Netscape Navigator 3.0+, MS Internet Explorer 3.02+, or comparable browser
- Dial-up Network: 16-bit TCP/IP stack and Dialer software
- Plug-in/Helper software: Adobe Acrobat Reader v3.01+

A direct dial-up modem connection may be established using Windows Dial-Up Networking or equivilant software. To establish a new Dial-up Network connection, use the following settings:
- Phone number: 301 227-4444
- Dial-up Protocol: PPP
- Enable Software Compression: Yes
- Log on to Network: No
- Require Encrypted Password: No
- Enable TCP/IP protocol: Yes
- Server Assigned IP Address: Yes
- DNS Server IP Address: 164.214.12.67
- Primary and Secondary WINS configuration: 0.0.0.0 (default)
- User IP Header Compression: Yes
- Use Default Gateway on Remote Network: No

When the connection is established, start the Internet browser software and enter the URL http://pollux.nss.nima.mil/. Be sure to disconnect the Dial-up Network connection when finished. Users with an Internet Service Provider (ISP) may reach the Marine Navigation website via the NIMA homepage at http://www.nima.mil by selecting the Maps & Geodata link, then the Marine Navigation Home Page link.

For further information concerning the NAVINFONET convey the request to:

MARINE NAVIGATION DEPARTMENT
ST D 44
NATIONAL IMAGERY AND MAPPING AGENCY
NAVINFONET STAFF
4600 SANGAMORE ROAD
BETHESDA, MD 20816-5003

DESCRIPTION

(Lights, Buoys, RACONs, RAMARKs)

Information is tabulated in eight columns as follows:

Column 1: The number assigned to each light, RACON or RAMARK by this Agency. International numbers are listed below this number in italic type and in a cross reference in the back of the book. RACONs and RAMARKs located at a light are listed with the light. Those not located at a light are assigned separate numbers.

Column 2: Name and descriptive location of the light or buoy, RACON or RAMARK. A dash (-) or dashes (--) in this column is used to reduce repetition of principal geographic names. This column is intended to describe the location of the navigational aid and to distinguish it from others in proximity. Differences in type indicate the following:

Bold-faced: Lights intended for landfall or having a visibility (range) of 15 miles or more.

Italics: Floating aids.

ITALICS CAPITALS: Lightships and LANBYs.

Roman: All other lights not mentioned above.

Column 3: Approximate latitude and longitude of a navigational aid to the nearest tenth of a minute, intended to facilitate chart orientation (use column 2 and the appropriate chart for precise positioning).

Column 4: Light, buoy, RACON or RAMARK characteristic (see Characteristics of Lights chart for explanation of lights).

Column 5: Height of light in feet (Roman type) equivalent measurement (below) given in meters (Bold-faced type).

Column 6: Range. The distance, expressed in nautical miles, that a light can be seen in clear weather or that a RACON or RAMARK can be received.

Column 7: Description of the structure and its height in feet.

Note–Stripes are vertical. Bands are horizontal. The use of the term “diagonal stripes” is the exception.

Column 8: Remarks–sectors, fog signals, radar reflectors, minor lights close by, radiobeacons, storm signals, signal stations, radio direction finders, and other pertinent information.

Geographic names or their spellings do not necessarily reflect recognition of the political status of an area by the United States Government.

The names of lights may differ from geographic names on charts.

ABBREVIATIONS

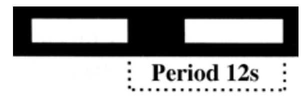
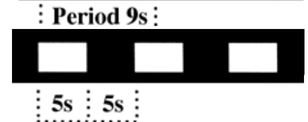
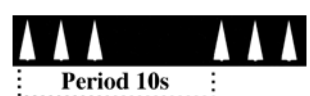
Where the lights of different countries intermingle in the list they are distinguished by the following letters:

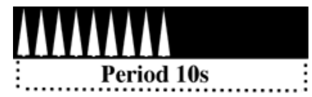
(Aus.)	Australia	(J.)	Japan
(C.)	China	(M.)	Malaysia
(F.)	France	(P.)	Portugal
(Ind.)	Indonesia	(T.)	Thailand
(In.)	Iran	(U.K.)	United Kingdom
(Iq.)	Iraq	(U.S.)	United States

Other abbreviations:

Al.—alternating	lt.—lit
bl.—blast	Mo.—Morse code
Bu.—blue	min.—minute
Dir.—directional	obsc.—obscured
ec.—eclipsed	Oc.—occulting
ev.—every	Or.—orange
F.—fixed	Q.—quick flashing
Fl.—flashing	R.—red
fl.—flash	s.—seconds
G.—green	si.—silent
horiz.—horizontal	U.Q.—ultra quick flashing
intens.—intensified	unintens.—unintensified
I.Q.— interrupted quick flashing	vert.—vertical
Iso.—isophase	Vi.—violet
I.V.Q.—interrupted very quick flashing	vis.—visible
Km.— kilometer (0.62137 mile)	V.Q.— very quick flashing
L.Fl.—long flashing	W.—white
	Y.—yellow

CHARACTERISTICS OF LIGHTS

TYPE	ABBR.	GENERAL DESCRIPTION	ILLUSTRATION
Fixed	F.	A continuous and steady light.	
Occulting	Oc.	The total duration of light in a period is longer than the total duration of darkness and the intervals of darkness (eclipses) are usually of equal duration. Eclipse regularly repeated.	
Group occulting	Oc.(2)	An occulting light for which a group of eclipses, specified in number, is regularly repeated.	
Composite group occulting	Oc.(2+1)	A light similar to a group occulting light except that successive groups in a period have different numbers of eclipses.	
Isophase	Iso.	A light for which all durations of light and darkness are clearly equal.	
Flashing	Fl.	A light for which the total duration of light in a period is shorter than the total duration of darkness and the appearances of light (flashes) are usually of equal duration (at a rate of less than 50 flashes per minute).	
Long flashing	L.Fl.	A single flashing light for which an appearance of light of not less than 2 sec. duration (long flash) is regularly repeated.	
Group flashing	Fl.(3)	A flashing light for which a group of flashes, specified in number, is regularly repeated.	
Composite group flashing	Fl.(2+1)	A light similar to a group flashing light except that successive groups in a period have different numbers of flashes.	
Quick flashing	Q.	A light for which a flash is regularly repeated at a rate of not less than 50 flashes per minute but less than 80 flashes per minute.	
Group quick flashing	Q.(3)	A light for which a specified group of flashes is regularly repeated; flashes are repeated at a rate of not less than 50 flashes per minute but less than 80 flashes per minute.	
	Q.(9)		
	Q.(6)+L.Fl.		

TYPE	ABBR.	GENERAL DESCRIPTION	ILLUSTRATION
Interrupted quick flashing	I.Q.	A light for which the sequence of quick flashes is interrupted by regularly repeated eclipses of constant and long duration.	
Very quick flashing	V.Q.	A light for which a flash is regularly repeated at a rate of not less than 80 flashes per minute but less than 160 flashes per minute.	
Group very quick flashing	V.Q.(3)	A light for which a specified group of very quick flashes is regularly repeated.	
	V.Q.(9)		
	V.Q.(6)+L.Fl.		
Interrupted very quick flashing	I.V.Q.	A light for which the sequence of very quick flashes is interrupted by regularly repeated eclipses of constant and long duration.	
Ultra quick flashing	U.Q.	A light for which a flash is regularly repeated at a rate of not less than 160 flashes per minute.	
Interrupted ultra quick flashing	I.U.Q.	A light for which the sequence of ultra quick flashes is interrupted by regularly repeated eclipses of constant and long duration.	
Morse code	Mo.(U)	A light for which appearances of light of two clearly different durations are grouped to represent a character or characters in Morse Code.	
Fixed and flashing	F.Fl.	A light for which a fixed light is combined with a flashing light of greater luminous intensity.	
Alternating light	Al.	A light showing different colors alternately.	

NOTE - Alternating lights may be used in combined form with most of the previous types of lights.

NOMENCLATURE OF LIGHTS

Lights exhibit a distinctive appearance by which they are recognized, e.g. Fixed, Flashing, Group Flashing, etc. The properties of their appearance, by which they are distinguished, are referred to as the *characteristics* of the light. The principal characteristics are generally the sequence of intervals of light and darkness, and, in some cases, the sequence of colors of light exhibited.

Fixed lights—those which exhibit a continuous steady light.

Rhythmic lights—those which exhibit a sequence of intervals of light and eclipse (repeated at regular intervals) in a manner described in Chart No. 1 and this volume.

Alternating lights—rhythmic lights which exhibit different colors during each sequence.

Period of a light—the time occupied by an entire cycle of intervals of light(s) and eclipse(s).

Range: Meteorological visibility—the greatest distance at which a black object of suitable dimensions can be seen and recognized against the horizon sky or, in the case of night observations, could be seen and recognized if the general illumination were raised to the normal daylight level.

Luminous range of a light—the greatest distance at which a light can be seen merely as a function of its luminous intensity, the meteorological visibility, and the sensitivity of the observer's eyes.

Nominal range of the light—the luminous range of a light in a homogeneous atmosphere in which the meteorological visibility is 10 nautical miles.

Geographical range of a light—the greatest distance at which a light can be seen as a function of the curvature of the earth, the height of the light source and the height of the observer.

The visibility of a light is usually the distance that it can be seen in clear weather and is expressed in nautical miles. Visibilities listed are values received from foreign sources.

Range lights—two or more lights at different elevations, so situated to form a range (leading line) when brought into transit. The light nearest the observer is the *front light* and the one farthest from the observer is the *rear light*. The front light is normally at a lower elevation than the rear light.

Directional lights—lights illuminating a sector of very narrow angle and intended to mark a direction to be followed.

Vertical lights—Two or more lights disposed vertically or geometrically to form a triangle, square, or other figure. If the individual lights serve different purposes, those of lesser importance are called *Auxiliary lights*.

Occasional lights—lights exhibited only when specially needed:

(a) *Tidal light*—shown at the entrance of a harbor, to indicate tide and tidal current conditions within the harbor.

(b) *Fishing light*—for the use of fishermen and shown when required.

(c) *Private light*—maintained by a private authority for its own purposes. The mariner should exercise special caution when using a private light for general navigation.

Seasonal lights—usually shown only during the navigation season or for a lesser time period within that season.

Articulated lights—offshore aids to navigation consisting of a length of pipe attached directly to a sinker by means of a pivot or such other device employing the principle of the universal joint. The positional integrity is intermediary between that of a buoy and a fixed aid.

Aeronautical lights—lights of high intensity which may be the first lights observed at night from vessels approaching the coast. Those lights situated near the coast are listed in the List of Lights in order that the navigator may be able to obtain more information concerning their description.

These lights are not designed or maintained for marine navigation and they are subject to change without prompt notification.

These lights are indicated in this List by the designation AVIATION LIGHT and are placed in geographical sequence in the body of the text along with lights for surface navigation.

Aeromarine lights—marine-type lights for which part of the beam is deflected to an angle of 10 to 15 degrees above the horizon to facilitate use by aircraft.

Sector limits and arcs of visibility—these are arranged clockwise and are given from seaward toward the light. Thus, in the diagram, the sectors of the light are defined as: obscured from shore to 315˚, red to 358˚, green to 050˚, white to shore. These are bearings of the light as seen from a vessel crossing the sector lines.

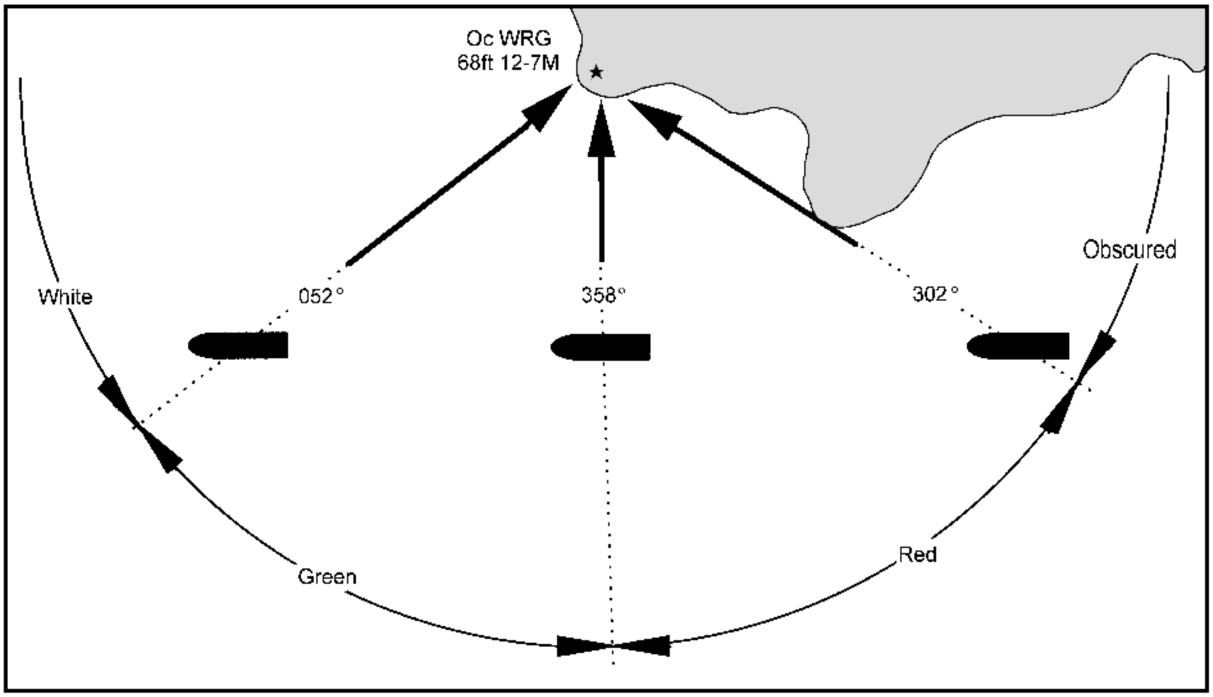
Under some conditions of the atmosphere, white lights may have a reddish hue. The mariner should not judge solely by color where there are sectors but should verify this position by taking a bearing of the light. On either side of the line of demarcation between white and red there is always a small sector of uncertain color, as the edges of a sector of visibility cannot be clearly defined.

When a light is obscured by adjoining land and the arc of visibility is given, the bearing on which the light disappears may vary with the distance from which it is observed. When the light is cut off by a sloping point of land or hill, the light may be seen over a wider arc by a ship farther off than by one closer.

Bearings—all bearings are true, measured clockwise from 000˚, and given in degrees or degrees and minutes.

Russian lights are shown throughout the winter when icebreakers are working.

The latest *Russian* charts and publications give only sufficient details for navigation to the ports open to international trade. Thus, in this volume, only those lights along the routes to such ports can be assumed to be correct. Elsewhere the latest available information, often not recent, is listed.



LIGHTSHIPS, SUPERBUOYS, AND OFFSHORE LIGHT STATIONS

Courses should be set to pass all floating aids to navigation with sufficient clearance to avoid the possibility of collision from any cause. Experience shows that floating aids to navigation cannot be safely used as leading marks to be passed close aboard, but should always be left broad off the course, whenever searoom permits.

When approaching a lightship, superbuoy, or a station on a submarine site on radio bearings, the risk of collision will be avoided by insuring that the radio bearing does not remain constant.

Most lightships and large buoys are anchored with a very long scope of chain and, as a result, the radius of their swinging circle is considerable. The charted position is the location of the anchor. Furthermore, under certain conditions of wind and current, they are subject to sudden and unexpected sheers which are certain to hazard a vessel attempting to pass close aboard.

During extremely heavy weather and due to their exposed locations, lightships may be carried off station. The mariner should, therefore, not implicitly rely on a lightship maintaining its precisely charted position during and immediately following severe storms. A lightship known to be off station will secure her light, fog signal, and radiobeacon and fly the International Code signal "LO" signifying "I am not in my correct position."

Lightships in *India* carry a white riding light on the forestay.

The following regulations have been established for lightships in the Hugli River:

A white light is exhibited from the forestay of each lightship, at a height of 2m, above the rail, for the purpose of showing in which direction the vessel is riding when at her station. Attended lightships out of position will not display their distinguishing mark; at night, the station light will be extinguished, a fixed red light shown at the bow and stern and red and white flares burnt every 15 minutes. If an attended lightship is in danger and requires assistance from shore, explosive rockets will be fired by day and, during fog, a bell will be rung at intervals of about 1 minute only when in danger of collision.

From 15 March to 31 October the pilot vessel on duty at Sandheads will exhibit, every 15 minutes between sunset and sunrise, a searchlight beam at an elevation of 30˚. The light will be revolved from east, through south, to west and back again, the total period being 2 minutes.

Indonesian lights are unreliable, being frequently irregular or extinguished.

Lightships in *Iraq*, when out of position, will discontinue their characteristic lights and fog signals. They will show instead two black balls, one forward and one aft, or two red lights, one forward and one aft. In addition they will hoist the signal "LO" or will show a red and a white light, or flare-up light, every 15 minutes. Red flags may be used instead of the black ball.

A lightship under way shows the same lights, and makes the same sound signals as other vessels under way, and by day hoists two black balls or red flags, one forward and one aft.

Korean lights are unreliable, being frequently irregular or extinguished.

Lights in the *Philippines* are unreliable, being frequently irregular or extinguished.

Lightships in *Thailand*, when out of position, discontinue their characteristic lights. They will show instead two black balls, one forward and one aft, and hoist the signal "LO" at the yardarm, or will show two red lights, one forward and one aft, and a white light simultaneously at least every 15 minutes.

The latest *Russian* charts and publications give only sufficient details for navigation to ports open to international trade. Thus, in this volume, only those lights along the routes to such ports can be assumed to be correct. Elsewhere the latest available information, often not of very recent date, is listed.

Lightships remain on their stations during the period of navigation only; if forced to leave stations on account of ice they are replaced as soon as possible.

By day they show a ball over a yellow flag with a blue St. George's cross and, by night, carry a white riding light. If a vessel is seen to be running into danger the signal "NF" of the International Code of Signals is hoisted, and if not immediately seen, rockets with two explosions and bright stars may be fired every minute; by night rockets only are used.

When not on their proper stations, the light vessels discontinue their characteristic lights and fog signals and, if possible, will lower their daymarks. They will show instead two black balls, one forward and one aft, or two red lights, one forward and one aft. In addition they will hoist the signal "LO" or show a red and a white flare-up light or flash simultaneously, at least every 15 minutes.

Red flags may be displayed in place of the black balls and red and a white light shown simultaneously may be used in place of the flare-up light or flash.

A lightship under way shows the same lights and makes the same sound signals as other vessels under way and, if preceding under its own power, hoists two black balls, one forward and one aft.

Reserve lightships are painted red and equipped with two masts. By day they display a red ball at each mast, and by night exhibit a fixed red light from the same positions. Fog signals are sounded and the warning signals described above are employed.

Fog bells at lighthouses and lightvessels are sounded, unless otherwise stated in the following uniform manner:

(a) at lighthouses: in groups of double strokes, the interval between the groups being not more than 3 minutes.

(b) at lightships: in groups of triple strokes, the interval between the groups being not more than 2 minutes.

When the fog signal of an approaching vessel is heard, the intervals between the double and triple strokes in the groups are reduced and the bell is sounded continuously in double or triple strokes until the vessel is past the light or clear of danger.

FOG SIGNALS

The function of a fog signal in the system of aids to navigation is to warn of danger and to provide the mariner with an audible means of approximating his position relative to the fog signal when the station, or any visual signal which it displays, is obscured from view by atmospheric conditions.

Fog signals depend upon the transmission of sound through air. As aids to navigation, they have certain inherent defects that should be considered. Sound travels through the air in a variable and frequently unpredictable manner.

It has been established that:

(a) fog signals are heard at greatly varying distances and that the distance at which a fog signal can be heard may vary with the bearing of the signal and may be different on different occasions;

(b) under certain conditions of atmosphere, when a fog signal has a combination of high and low tones, it is not unusual for one of the tones to be inaudible. In the case of sirens, which produce a varying tone, portions of the blast may not be heard;

(c) there are occasionally areas close to the signal in which it is wholly inaudible. This is particularly true when the fog signal is screened by intervening land or other obstructions;

(d) fog may exist a short distance from a station and not be observable from it, so that the signal may not be in operation;

(e) even though a fog signal may not be heard from the deck or bridge of a ship when the engines are in motion, it may be heard when the ship is stopped, or from a quiet position. Sometimes it may be heard from aloft though not on deck;

(f) the intensity of the sound emitted by a fog signal may be greater at a distance than in immediate proximity.

All these considerations point to the necessity for the utmost caution when navigating near land in fog. Particular attention should be given to placing lookouts in positions in which the noises in the ship are least likely to interfere with hearing a fog signal. Fog signals are valuable as warnings, but the mariner should not place implicit reliance upon them in navigating his vessel. They should be considered solely as warning devices.

Among the devices in common use as fog signals are:

Radiobeacons which broadcast simple dot-and-dash combinations by means of a transmitter emitting modulated continuous waves;

Diaphones which produce sound by means of a slotted reciprocating piston actuated by compressed air. Blasts may consist of two tones of different pitch, in which case the first part of the blast is high and the last of a low pitch. These alternate pitch signals are called “two-tone;”

Diaphragm horns which produce sound by means of a diaphragm vibrated by compressed air, steam, or electricity. Duplex or triplex horn units of differing pitch produce a chime signal;

Nautophones, electrically operated instruments, each comprising a vibrating diaphragm, fitted with a horn, which emits a high note similar in power and tone to that of the reed;

Reed horns which produce sound by means of a steel reed vibrator by compressed air;

Sirens which produce sound by means of either a disk or a cup-shaped rotor actuated by compressed air or electricity;

Whistles which produce sound by compressed air emitted through a circumferential slot into a cylindrical bell chamber;

Bells which are sounded by means of a hammer actuated by hand, wave motion, by a descending weight, compressed gas, or electricity;

Guns and explosive signals which are produced by firing of explosive charges, the former being discharged from a gun, and the latter being exploded in midair;

Fog Detector Lights—certain light stations, in addition to the main light, are equipped with fog detector lights for automatic detection of fog. These lights sweep back and forth through an area over which the fog watch is necessary, showing a powerful bluish-white flash of about 1 second in duration. The interval between successive flashes will vary with the position of the vessel within the sector. At the limits of the sector the duration of the flash may be considerably longer than 1 second.

Fog detector lights operate continuously.

Standby fog signals are sounded at some of the light and fog signal stations when the main fog signal is inoperative. Some of these standby fog signals are of a different type and characteristic than the main fog signal.

Radiobeacons, RACONs, RAMARKs, and radio direction-finders are mentioned in the List of Lights, but for detailed information, including the synchronization of radio signals and sound signals for distance finding, the navigator should consult Pub. 117, Radio Navigational Aids.

Note—use Chart No. 1 for the complete list of symbols and abbreviations commonly used in presenting the essential characteristics of lights, fog signals, and radio aids found on charts.

VISIBILITY TABLE

Table of distances at which objects can be seen at sea according to their respective elevations and the elevation of the eye of the observer.

Height in Feet	Distance in geographic or nautical miles	Height in feet	Distance in geographic or nautical miles	Height in feet	Distance in geographic or nautical miles	Height in feet	Distance in geographic or nautical miles	Height in feet	Distance in geographic or nautical miles	Height in feet	Distance in geographic or nautical miles
1	1.2	23	5.6	45	7.8	135	13.6	340	21.6	600	28.7
2	1.7	24	5.7	46	7.9	140	13.8	350	21.9	620	29.1
3	2.0	25	5.9	47	8.0	145	14.1	360	22.2	640	29.5
4	2.3	26	6.0	48	8.1	150	14.3	370	22.5	660	30.1
5	2.6	27	6.1	49	8.2	160	14.8	380	22.8	680	30.5
6	2.9	28	6.2	50	8.3	170	15.3	390	23.1	700	31.0
7	3.1	29	6.3	55	8.7	180	15.7	400	23.4	720	31.4
8	3.3	30	6.4	60	9.1	190	16.1	410	23.7	740	31.8
9	3.5	31	6.5	65	9.4	200	16.5	420	24.0	760	32.3
10	3.7	32	6.6	70	9.8	210	17.0	430	24.3	780	32.7
11	3.9	33	6.7	75	10.1	220	17.4	440	24.5	800	33.1
12	4.1	34	6.8	80	10.5	230	17.7	450	24.8	820	33.5
13	4.2	35	6.9	85	10.8	240	18.1	460	25.1	840	33.9
14	4.4	36	7.0	90	11.1	250	18.5	470	25.4	860	34.3
15	4.5	37	7.1	95	11.4	260	18.9	480	25.6	880	34.7
16	4.7	38	7.2	100	11.7	270	19.2	490	25.9	900	35.1
17	4.8	39	7.3	105	12.0	280	19.6	500	26.2	920	35.5
18	5.0	40	7.4	110	12.3	290	19.9	520	26.7	940	35.9
19	5.1	41	7.5	115	12.5	300	20.3	540	27.2	960	36.3
20	5.2	42	7.6	120	12.8	310	20.6	560	27.7	980	36.6
21	5.4	43	7.7	125	13.1	320	20.9	580	28.2	1000	37.0
22	5.5	44	7.8	130	13.3	330	21.3				

Explanation.—The line of sight connecting the observer and a distant object is at maximum length tangent with the spherical surface of the sea. It is from this point of tangency that the tabular distances are calculated. The table must accordingly be entered twice to obtain the actual geographic visibility of the object—first with the height of the object, and second with the height of the observer's eye—and the two figures so obtained must be added. Thus, if it is desired to find the maximum distance at which a powerful light may be seen from the bridge of a vessel where the height of eye of the observer is 55 feet above the sea, from the table:

	Nautical Miles
55 feet height of observer (visible)	8.7
200 feet height of light(visible)	16.5
Distance visible	25.2

CONVERSION TABLE — FEET TO WHOLE METERS

(FOR HEIGHTS OF LIGHTS)
1 foot = 0.3048 meter

Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
		40	12	80	24	120	37	160	49	200	61
1	0	41	12	81	25	121	37	161	49	300	91
2	1	42	13	82	25	122	37	162	49	400	122
3	1	43	13	83	25	123	37	163	50	500	152
4	1	44	13	84	26	124	38	164	50	600	183
5	2	45	14	85	26	125	38	165	50	700	213
6	2	46	14	86	26	126	38	166	51	800	244
7	2	47	14	87	27	127	39	167	51	900	274
8	2	48	15	88	27	128	39	168	51	1000	305
9	3	49	15	89	27	129	39	169	52		
10	3	50	15	90	27	130	40	170	52		
11	3	51	16	91	28	131	40	171	52		
12	4	52	16	92	28	132	40	172	52		
13	4	53	16	93	28	133	41	173	53		
14	4	54	16	94	29	134	41	174	53		
15	5	55	17	95	29	135	41	175	53		
16	5	56	17	96	29	136	41	176	54		
17	5	57	17	97	30	137	42	177	54		
18	5	58	18	98	30	138	42	178	54		
19	6	59	18	99	30	139	42	179	55		
20	6	60	18	100	30	140	43	180	55		
21	6	61	19	101	31	141	43	181	55		
22	7	62	19	102	31	142	43	182	55		
23	7	63	19	103	31	143	44	183	56		
24	7	64	20	104	32	144	44	184	56		
25	8	65	20	105	32	145	44	185	56		
26	8	66	20	106	32	146	45	186	57		
27	8	67	20	107	33	147	45	187	57		
28	9	68	21	108	33	148	45	188	57		
29	9	69	21	109	33	149	45	189	58		
30	9	70	21	110	34	150	46	190	58		
31	9	71	22	111	34	151	46	191	58		
32	10	72	22	112	34	152	46	192	59		
33	10	73	22	113	34	153	47	193	59		
34	10	74	23	114	35	154	47	194	59		
35	11	75	23	115	35	155	47	195	59		
36	11	76	23	116	35	156	48	196	60		
37	11	77	23	117	36	157	48	197	60		
38	12	78	24	118	36	158	48	198	60		
39	12	79	24	119	36	159	48	199	61		

RADIOBEACONS

RADIO DIRECTION-FINDER SETS ON SHIPS

Radio direction-finder sets on board ship enable bearings to be taken of transmissions from other ships, aircraft, shore stations, marine radiobeacons, and the coastal stations of the radio communication network. When located in the pilothouse or on the navigating bridge, the direction-finder enables the navigating officer to obtain bearings himself without reference to others and without delay.

Due to the great value of radio bearings, particularly when visibility is poor and when celestial observations cannot be obtained, the radio direction-finder on board ship deserves the same consideration and care as are given to the sextant and compass. It has the following characteristics in common with the two latter navigational instruments: the readings are subject to certain errors; these errors may be reduced by skillful and intelligent operation; the dangers of using erroneous readings may be greatly reduced by the intelligence and good judgment of the mariner. In order to acquire experienced judgment in the operation of the instrument, it is essential that the mariner use it as much as practicable.

Troubles from interference and weak signals are greatly reduced by the use of direction-finders of proper selectivity. The bearings must be corrected for radio deviation as shown by the calibration curve of the set.

Types of Radiobeacons

1. Directional radiobeacons which transmit radio waves in beams along fixed bearings.
2. Rotating radiobeacons by which a beam of radio waves is resolved in azimuth in a manner similar to the beam of light sent out by rotating lights.
3. Circular radiobeacons which send out waves of approximately uniform strength in all directions so that ships may take radio bearings of them by means of the ship's radio direction-finder sets. This is the most common type of radiobeacon.

To extend the usefulness of marine radiobeacons to ships and aircraft employing automatic radio direction finders, U.S. marine radiobeacons on the Atlantic and Pacific Coasts and Great Lakes have been modified to transmit a continuous carrier signal during the entire radiobeacon operating period with keyed modulation providing the characteristic signal. Unless a beat frequency oscillator is installed, the continuous carrier signals are not audible to the operator of an aural null direction finder. A ten second dash has been included in the characteristic of these radiobeacons, to enable the navigator using a conventional aural null direction finder to refine his bearing. Vessels with direction finders will be able to use the United States radiobeacons located on the Atlantic and Pacific Coasts, and Great Lakes at any time in their assigned sequence.

Aeronautical Radio Aids

Aeronautical radiobeacons and radio ranges are often used by navigators of marine craft in the same manner as marine radiobeacons are used for determining lines of positions. They are particularly useful along coasts where marine broadcast coverage is inadequate. Aeronautical aids situated inland become less trustworthy, so far as ships are concerned, when high land intervenes between them and the coast. They are established to be of primary usefulness to aircraft, and surface craft should use these aids with caution. Only those aeronautical radiobeacons considered to be of use to the mariner have been selected for inclusion in this publication.

AERONAUTICAL RADIOBEACONS. Like marine radiobeacons, these aids broadcast a characteristic signal on a fixed frequency.

NOTE: The assigned frequency of aeronautical radiobeacons is normally from 200 to 415 kHz while the frequency of marine radiobeacons is normally from 285 to 325 kHz. Aeronautical radiobeacons not within the marine radiobeacon band will not normally be listed in this publication.

The range signals are interrupted at intervals to permit broadcast of the identification signal. In aviation publications the range leg bearings are most often given as magnetic bearings toward the station; in this publication they are given as true bearings toward the station. Unless otherwise stated in the station details, aeronautical radio aids mentioned in this publication transmit continuously.

NOTE: Mariners are advised that changes to and deficiencies in aeronautical radio facilities are not always immediately available to maritime interests and the positions are approximate and listed to the nearest minute only.

Obligations of Administrations Operating Radiobeacons

The obligations of nations and other administrations operating radiobeacons are given in Article 43 of the Radio Regulations of the International Telecommunication Union, Geneva.

Accuracy of Bearings Taken Aboard Ship

No exact rules can be given as to the accuracy to be expected in radio bearings taken by a ship as the accuracy depends to a large extent upon the skill of the ship's operator, the condition of the ship's equipment, and the accuracy of the ship's calibration curve. Mariners are urged to obtain this information by taking frequent radio bearings when their ship's position is accurately known and by recording the results. Normally, United States radiobeacons are operated in a group of six, each station in a group using the same frequency and transmitting for one minute in its proper sequence, and operate during all periods, either sequenced or continuously, regardless of weather conditions.

SKILL OF OPERATOR: Skill in the operation of the radio direction-finder can be obtained only by practice and by observing the technical instructions for the set in question. For these reasons the operator should carefully study the instructions issued with the set and should practice taking bearings frequently.

OPERATOR'S ERROR: As the operator obtains bearings by revolving the direction-finder coil until the signal disappears or becomes a minimum, the operator can tell by the size of the arc of silence or of minimum strength approximately how accurately the bearing has been taken. For instance, if the minimum is broad and the residual signal covers about 10˚ with equal strength, it is doubtful if the bearing can be accurately estimated. On the other hand, if a sharp minimum can be obtained, the operator can determine the bearing to within a half of a degree.

In this connection it should be noted that a properly operating and correctly adjusted direction-finder should in no case produce other than a point or arc of absolute silence. That is, there should be no "residual" signal at the point or arc of observation. The sharpness and completeness of the arc of silence are the best indications of a properly operating direction-finder, and their absence is the best indication of the presence of "night effect."

SUNRISE, SUNSET, OR NIGHT EFFECT: Bearings obtained from about half an hour before sunset to about half an hour after sunrise may be subject to errors due to night effect. On some nights this effect is more pronounced than on others and effect is usually greatest during the hours of twilight. Night effect may be detected by a broadening of the arc of minimum signals and by a fluctuation in the strength of the signals. It may also be indicated by difficulty in obtaining a minimum or by a rapidly shifting minimum. It is sometimes accompanied by an actual shift in the direction of the bearings. If it is essential to obtain a bearing when the night effect is pronounced, several bearings should be taken over a short period of time and an average taken of them.

RADIO DIRECTION FINDER WITHOUT GYRO REPEATERS: The ship's compass must be read as the bearing is taken or an error may be introduced equal to the amount that the ship has yawed in the interval between taking the bearing and reading the compass. Any error in the ship's compass must be applied to the bearing.

RECIPROCAL BEARINGS: In some direction-finder sets, the operator cannot tell from which side of the ship the signals are coming. With these sets the operator shall correct both bearings for their respective deviations and give both corrected bearings to the person who is plotting the bearings on the chart. If the mariner is in doubt as to the side of the ship from which the bearings are coming, this difficulty can usually be solved by having another bearing taken after the ship has steamed a short distance and noting in which direction the bearing is changing.

CALIBRATION: It is essential that the radio direction-finder be accurately calibrated in order that the bearings may be corrected for deviation. While the bearings are being taken, other radio antennas on board must be in the same condition as they were when the calibration was made; movable parts of the ship's superstructure such as booms, davits, wire rigging, etc., must be secured in the positions which they occupied when the direction-finder was calibrated. Unusual cargoes such as large quantities of metals and extraordinary conditions of loading may cause errors.

The direction-finder should be recalibrated after any changes have been made in the set or its surroundings (this includes alterations to or changes in position of antennas, wire rigging, boat davits, booms, etc.) whenever there is reason to believe that the previous calibration has become inaccurate, and also at periodic intervals.

The calibration must be made on approximately the same frequency or frequencies as will be used to take bearings because the deviation for several frequencies is not likely to be the same. It is believed that one calibration curve is satisfactory for the normal radiobeacon frequency (285 to 325 kHz), but the instructions issued by the manufacturer of the particular direction-finder in question should be studied in this connection.

To facilitate the calibration of ship's direction-finders, special arrangements have been made by some services for operation of their radiobeacons at times other than their published schedules. Information as to the arrangements made by the United States stations in this respect is as follows:

Sequenced radiobeacons cannot broadcast at any time other than on their assigned operating minute for the purpose of enabling vessels to calibrate their radio direction finders without causing interference. Special radio direction finder calibration transmitters of short range are operated at certain localities to provide continuous calibration service.

The position given for the antenna is the point from which the radiobeacon signal is emitted.

If it is not practicable to determine the time of calibration sufficiently in advance to contact the district commander, request may be made directly to the stations by means of telephone, telegraph, or a whistle signal consisting of three long blasts; followed by three short blasts.

This whistle signal is to be repeated until it is acknowledged by the station through the starting of the transmitter. The same group of signals should be sounded at the termination of calibration.

The work of the station personnel is not confined to standing watch and there may be times when the whistle request for calibration is not immediately heard, due to the noise from operating station machinery, etc. Usually, a repeated signal not too far from the station will attract attention.

"COMPENSATED" RADIO DIRECTION-FINDERS: Many radio direction-finders are "compensated" and no calibration chart or curve is used. Attention is invited to the fact that such compensation is just as vulnerable as the calibration data due to changes made in the set or its surroundings.

CHECK THE CALIBRATION: The calibration of compensation should be checked frequently by taking bearings when the ship's position is accurately known and the results should be recorded for future reference.

CALIBRATION RADIOBEACONS: In the United States and certain other areas special radiobeacons, primarily for calibrating shipboard direction-finders are in operation. These radiobeacons transmit either continuously during scheduled hours or upon request, as indicated in station details.

COASTAL REFRACTION (OR LAND EFFECT): Errors may occur in bearings taken by ships so located that the line of observation to the radiobeacon passes over land or along the shore line. However, many observations seem to indicate that such errors are negligible when the observing vessel is well out from the shore. Bearings secured entirely over water areas are to be preferred since "land effect" is thus eliminated. Bearings taken at sunset and sunrise are likely to be erratic, and observations taken at these hours should therefore be repeated and checked as may be feasible.

PROGRAM BROADCASTING STATIONS: Before taking bearings on a station broadcasting entertainment programs a mariner should consider that frequency may differ widely from the frequency for which the set is calibrated, that the published location of the station may be that of its studio and not that of its transmitting antenna, that if the station is synchronized with other stations it may be impossible to tell on which station the bearing was taken, and that as the majority of these stations are inland, the coastal refraction may be excessive.

Station Details

FREQUENCY: The frequency listed is that used by the station in transmitting its "Characteristic Signal." Calling frequencies, if any, will be given under "remarks."

RANGE: In this book the range of radiobeacons is only approximate and is given merely to assist mariners in planning their voyages and to inform them of several radiobeacons they will probably hear first. Frequently, when conditions for radio reception are good, radiobeacons may be heard at greater distances than indicated. The mariner who is at a greater distance than the range indicated should attempt to obtain bearings when necessary, and not assume that the radiobeacon will be unheard beyond its indicated range.

GROUP SEQUENCE: Selected radiobeacons are grouped together on the same operating frequency and are assigned a specific sequence of transmission within this group. This reduces station interference and unnecessary returning.

ANTENNA LEAD-IN: Included in the details of many radiobeacons located at or near light stations is a statement of the distance and bearing of the radiobeacon transmitting antenna from the light tower. Use should be made of this information when calibrating the ship's direction-finding equipment by means of simultaneous visual and radio bearings.

Plotting Radio Bearings

The procedure for converting radio (great circle) bearings as received by direction-finder equipment aboard ship is identical with that used in converting radio bearings supplied by direction-finder stations on shore and is described in section 100E "Plotting Radio Bearings" of Pub. 117, Radio Navigational Aids.

Synchronization for Distance Finding

At some radiobeacon stations, sound signals, either submarine or air or both, are synchronized with the radiobeacon signals for distance finding. Ordinarily, the sound signals do not operate during the transmission period of the radio signal in clear weather. The methods in use employ, as a rule, distinctive signals to indicate the point of synchronization, and make use, for determining distance, of the lag of signals traveling through air or water as compared to the practically instantaneous travel of the radio signals.

In the case of some sound signals, a series of short radio dashes is transmitted at intervals following the synchronizing point, so that by counting the number of such short dashes heard after the distinctive radio signal and before hearing the corresponding distinctive sound signal, the observer obtains the distance, in miles equal to the number of dashes counted, from the sound signal apparatus unless stated otherwise.

In the case of other signals, the observer notes the number of seconds intervening between the reception of the distinctive radio signal and the corresponding sound signal and uses a factor to determine distances in miles as follows:

Submarine signals–multiply the observed numbers of seconds by 0.8 or divide by 1.25 distance in nautical miles.

Air signals–multipy the observed number of seconds by 0.18 or divide by 5.5. For more approximate results or for statute miles, multiply the observed number of seconds by 0.2 or divide by 5.

Tables for finding distance

Interval in seconds	Distances in nautical miles from sound signal source	
	Air	Submarine
1	0.18	0.8
2	0.36	1.6
3	0.54	2.4
4	0.72	3.2
5	0.90	4.0
6	1.08	4.8
7	1.26	5.6
8	1.44	6.4
9	1.62	7.2
10	1.80	8.0
20	3.60	16.0
30	5.40	24.0
40	7.20	
50	9.00	
60	10.80	

REMARKS: Average speed of sound travel in water is 1 nautical mile in 11/4 seconds.

The speed of sound travel is influenced by a number of conditions making it impracticable to state a factor that will give exact results under all conditions. The results obtained by the methods described may be accepted as being accurate to within 10 percent of the distance.

Methods of synchronizing the signals vary and are described or illustrated in official announcements regarding them. It is essential to note carefully the point of synchronization used so that no error will be made through taking time on the wrong signal or the wrong part of it.

In observing air signals it is usually sufficient to use a watch with second hand, although a stop watch is helpful. For submarine signals where the interval is shorter and a time error correspondingly more important, it is essential that a stop watch or other timing device be used. Where the radiobeacon and submarine signals are not received at the same point on the vessel, means of instant communication between two observers should be available or synchronized stop watches provided for each.

Ships not equipped with a DF receiver can take advantage of the distance-finding feature of a radiobeacon station, if equipped with a radio receiver capable of receiving the transmission. In the case of obtaining distance from a radiobeacon station which is synchronized with a submarine sound signal, the ship must also be equipped with a device for picking up submarine sound signals.

Rotating Loop Radiobeacon

MODE OF OPERATION:

(1) The radiobeacon consists of a rotating loop transmitter having directional properties by which an observer in a ship can obtain his bearing from the beacon without the use of a direction-finder. Any ordinary receiving set capable of being tuned to the radiobeacon's frequency may be used. The only other equipment required is a reliable stop watch or chronograph with a sweep second hand. Stop watches and clocks with dials graduated in degrees may be used, from which bearings may be read directly without any mathematical calculation.

(2) During each revolution of the beacon, the signals received by the observer will rise and fall in intensity, passing through a maximum and a minimum twice each minute. The positions of minimum intensity, which occur at intervals of thirty seconds from one another, are very sharp and can be accurately observed. These are, therefore, used for navigation purposes.

The beacon may be regarded as having a line or beam of minimum intensity which rotates at a uniform speed of 360˚ in 1 minute (i.e. 6˚ in 1 second) based on the true meridian as starting point. Therefore, if the observer can (a) identify the beacon and (b) measure the number of seconds which this minimum beam takes to reach their position starting from the true meridian, this number multiplied by six will give their true bearing from the beacon or its reciprocal.

The signals which enable the beacon to be identified and the bearing to be calculated are described in the following paragraphs:

Signals transmitted by the beacon: Each transmission from the beacon lasts for 4 minutes; the beacon is then silent for 8 minutes, and automatically starts again at the end of the silent period. Each transmission consists of two parts: (a) the identification signal of the station set at a slow speed for the first minute, commencing when the minimum beam is true east and west and followed by a long dash of about 12 seconds duration; (b) the signal group commencing when the minimum beam is approaching the true meridian, and consisting of (i) the north starting signal, which is the letter V followed by two dots (**••• – ••**); (ii) a long dash of about 12 seconds duration; (iii) the east starting signal, which is the letter B followed by two dots (**– ••• ••**); and (iv) a long dash for about 42 seconds.

The navigation signals are repeated during the remainder of the transmission and signals cease when the minimum beam is in the east and west position.

INSTRUCTIONS FOR TAKING BEARINGS

(i) Set stop watch to zero.
(ii) Listen for identification signal.
(iii) When the first long dash begins (at A on diagram) get ready for the "north signal."
(iv) After the "north signal," start stop watch exactly at beginning of long dash (see "00 seconds" on diagram) counting one-two with the two preceding dots, and 3 for the start of the stop watch.
(v) Listen for minimum and note its exact time by stop watch.

NOTE: If stop watch is graduated in degrees note exact angle, which is the bearing.

(vi) Multiply number of seconds by 6˚ for bearing.
(vii) Determine whether bearing is direct or reciprocal.
(viii) If the "north signal" is faint, use the "east signal," but add 090˚ to final bearing.

Particular attention is directed to the following:

(a) The stop watch must be started exactly at the beginning of the long dash for each series of observations.

(b) The time of occurrence of the minimum must be read to the nearest fifth of a second.

(c) The bearing obtained will be either the direct bearing or its reciprocal.

(d) When using the east signal, add 090˚ to obtain bearings from true north.

(e) The beacon is set up on the true meridian, and no correction is required for magnetic variation.

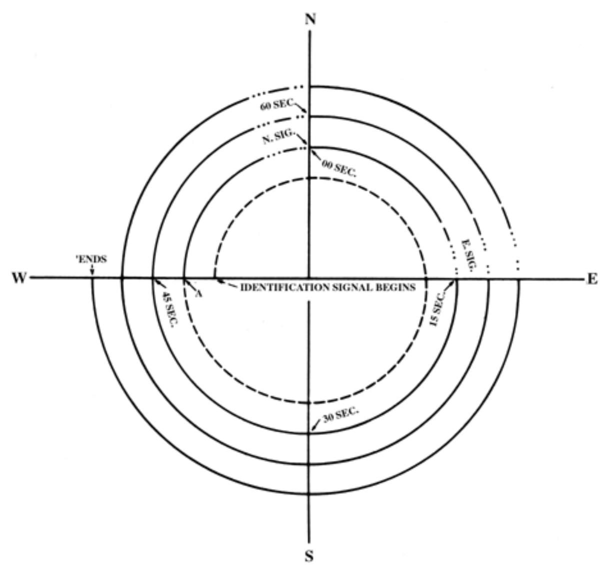
(f) No quadrantal error arises, and no corrections are necessary except as in (c) and (d) above.

(A correction must, of course, be made for convergency; this should be applied as if the beacon were a shore radio direction-finder station.)

(g) A comparatively large error of bearing may occur due to inaccuracy in the stop watch, and to obviate this, observers or navigators should check their stop watches on the beacon station before taking bearings. This can easily be done by checking the time by stop watch of the complete revolution of the beacon transmission. Any error found can then be allowed for.

Caution

Due to the many factors which enter into the transmission and reception of radio signals, a mariner cannot practically estimate its distance from a radiobeacon either by the strength of the signals received or by the time at which the signals were first heard. Mariners should give this fact careful consideration in approaching radiobeacons. A diagram showing the signals used is given below.



ROTATING RADIOBEACON
SIGNAL DIAGRAM

DESCRIPTION

(Radiobeacons)

Information is tabulated in eight columns as follows:

column 1: The number assigned to each radiobeacon by this Agency.

column 2: Name and/or descriptive location of the radiobeacon.

column 3: Approximate latitude and longitude of the radiobeacon to the nearest second.

column 4: Radiobeacon characteristics. Included in this column are the Morse code, period in seconds, length of transmission and silence time.

column 5: Range (approximate) in nautical miles.

column 6: Group sequence. Selected radiobeacons are grouped together on the same operating frequency and are assigned a specific sequence of transmission within this group. This reduces station interference and unnecessary return.

column 7: Frequency (given in kilohertz) and amplitude modulation (see Table Symbols).

column 8: Remarks. Transmission synchronization, type of radiobeacon (marine, aero, etc.), calibration, antenna lead-in, calling frequencies, distance-finding information, service charges, hours of transmission, directional signals and other pertinent information.

ABBREVIATIONS

aero . . . . aeronautical
tr . . . . transmission
si . . . . silence
s. . . . . .seconds
(4) . . . . 4 times
Transmission is continuous unless otherwise stated.

DIFFERENTIAL GLOBAL POSITIONING SYSTEM (DGPS)

Differential Global Positioning System (DGPS) is a radio-based navigation system that eliminates errors in a GPS receiver that will allow the accuracy level to be significantly enhanced. DGPS accuracy can be 10 meters or better, compared with 100 meters or better with GPS. This is possible by placing a high-performance GPS receiver (reference station) at a known location. Because the receiver knows its exact location, it can determine the errors in the satellite signals. The satellite measures the ranges to each satellite using the signals received and comparing these measured ranges to the actual ranges calculated from its known position. The total error is the difference between the measured and calculated range. The error data for each tracked satellite is formatted into a correction message and transmitted to GPS users. The correction message format follows the standard established by the Radio Technical Commission for Maritime Services, Special Committee 104 (RTCM-SC104). These differential corrections are then applied to the GPS calculations, thus removing most of the satellite signal error and improving accuracy.

Terms for understanding DGPS:

DGPS Correction Receiver

A DGPS correction receiver decodes the signals received from a reference site. Data is formatted into a serial RTCM SC104 data stream and provided to the remote GPS receiver. There are many types of DGPS correction receivers.

GPS Receivers

The GPS receiver measures ranges to each satellite, but before the measurements are used to calculate position, corrections received from the DGPS receiver are applied to the measurements. The position is then calculated using the corrected range measurements providing vastly increased accuracy.

Modulator

Depending on the transmission format, the modulator encodes the data as necessary for transmission.

Reference Station

The refrence station GPS receiver knows exactly the position of its antenna, therefore it knows what each satellite range measurement should be. It measures the ranges to each satellite using the received signals just as if it was going to calculate position. The measured ranges are subtracted from the known ranges and the result is range error. The range error values for each satellite are formatted into messages in the RTCM SC104 format and transmitted continuously.

Transmitter

The transmitter is basically a power amplifier which is connected to an antenna system. The modulated carrier is amplified and driven to the antenna. In the United States Coast Guard system, the transmitter is 250-1000 Watts and operates in the 300Khz frequency range. The amplified signal is radiated via the antenna to remote DGPS receivers for real-time position correction.

DESCRIPTION

(Differential GPS Stations)

Information is tabulated in eight columns as follows:

column 1: The number assigned to each DGPS Station by this Agency.

column 2: Name of the DGPS Station

column 3: Approximate latitude and longitude of the DGPS Transmitting Station to the nearest tenth of a minute.

column 4: Station ID which can be found in the IALA Master list. No two stations have the same ID. **T** dentoes the Transmitting Station, **R** denotes the Reference Station.

column 5: Range (approximate) in nautical miles.

column 6: Frequency in kHz.

column 7: Transfer Rate which equates to the baud rate and will be published as a whole number without any additional abbreviations such as “bps” (bits per second)

column 8: Remarks. This column contains information about the reference stations and messages types transmitted. GPS Message Type Numbers are 1, 3, 4, 5, 6, 7, 9, 15 and 16. *(Refer to message type descriptions below)*

GPS MESSAGE TYPE NUMBER INDICATORS

1	Differential GNSS corrections (full set of satellites)
3	Reference stations parameters
4	Datum used
5	Constellation health
6	Null frame (no information)
7	Radiobeacons Almanacs
9	Sub-set differential GNSS corrections
15	Ionospheric corrections
16	Special messages

TABLE OF SYMBOLS

LEGEND

(1) Type of modulation of the main carrier.
(2) Nature of signal(s) modulating the main carrier.
(3) Type of “information” to be transmitted. “Information” does not include information of a constant, unvarying nature such as provided by standard frequency emissions, continuous wave and pulse radars, etc.

AMPLITUDE MODULATION:

N0N

(1) Emission of an unmodulated carrier.
(2) No modulating signal.
(3) No information transmitted.

A1A

(1) Double-sideband.
(2) Single channel containing quantized or digital information without the use of a modulating subcarrier.
(3) Telegraphy (for aural reception).

A2A

(1) Double-sideband.
(2) Single channel containing quantized or digital information with the use of a modulating subcarrier.
(3) Telegraphy (for aural reception).

A3E

(1) Double-sideband.
(2) Single channel containing analog information.
(3) Telephony (including sound broadcasting).

R3E

(1) Single-sideband (reduced or variable level carrier).
(2) Single channel containing analog information.
(3) Telephony (including sound broadcasting).

B8E

(1) Independent sidebands.
(2) Two or more channels containing analog information.
(3) Telephony (including sound broadcasting).

H2A

(1) Single-sideband (full carrier).
(2) Single channel containing quantized or digital information with the use of a modulating subcarrier.
(3) Telegraphy (for aural reception).

H3E

(1) Single-sideband (full carrier).
(2) Single channel containing analog information.
(3) Telephony (including sound broadcasting).

J3E

(1) Single-sideband (suppressed carrier).
(2) Single channel containing analog information.
(3) Telephony (including sound broadcasting).

A3C

(1) Double-sideband.
(2) Single channel containing analog information.
(3) Facsimile.

A3F

(1) Double-sideband.
(2) Single channel containing analog information.
(3) Television (video).

B7D

(1) Independent sidebands.
(2) Two or more channels containing quantized or digital information.
(3) Data transmissions, telemetry, telecommand.
Note: With 6 kHz. EDW operation in the bands below 30 MHz allocated exclusively for Maritime Mobile Service (FC, MO).

FREQUENCY (OR PHASE) MODULATION:

F1B

(1) Frequency modulation.
(2) Single channel containing quantized or digital information without the use of a modulating subcarrier.
(3) Telegraphy (for automatic reception).

F2A

(1) Frequency modulation.
(2) Single channel containing quantized or digital information with the use of a modulating subcarrier.
(3) Telegraphy (for aural reception).

F3E

(1) Frequency modulation.
(2) Single channel containing analog information.
(3) Telephony (including sound broadcasting).

F3C

(1) Frequency modulation.
(2) Single channel containing analog information.
(3) Facsimile.

F3F

(1) Frequency modulation.
(2) Single channel containing analog information.
(3) Television (video).

P1B

(1) Sequence of unmodulated pulses.
(2) Single channel containing quantized or digital information without the use of a modulating subcarrier.
(3) Telegraphy (for automatic reception).

Pulse Modulation:
GHz = gigahertz
kHz = kilohertz
MHz = megahertz